

amount of correction required, the two chronometers are compared, usually by watching for a coincidence of beats. Knowing the error of the sidereal standard, by astronomical observation as described, the true sidereal time of comparison becomes known; the corresponding mean solar time is then easily calculated, and the error of the mean solar system of clocks immediately found. The commutator handle is then turned to throw a battery current into the accelerating and retarding coil, such as will attract or repel the pendulum magnet of the Mean Solar Standard, according as the clock is found to be slow or fast. The Mean Solar Standard and the various clocks in sympathy with it (those driven by it at Greenwich and those controlled by it at London) all receive the same correction, and are all brought to exact Greenwich mean time. By the arrangement described it will be seen that the Superintendent of the Time Department can at any time refer the Mean Solar system of clocks to the Sidereal Standard, and find and correct the error of the Mean Solar Standard and the whole system of mean solar clocks, whilst engaged in his ordinary office duties, and without moving from his position in the Computing Room. Correction is usually made every morning before 10h. A.M. (because at that hour an important distribution of time takes place), and again before 1h. P.M. (another important hour as regards time signals). The correction required is usually only a small fraction of a second.

Having shown how the error of the Sidereal Standard at Greenwich is found by astronomical observation, and from it that of the Mean Solar Standard, and lastly, how the latter clock is adjusted to exact time, we now proceed to describe the arrangements for giving time signals to the external world. A galvanic circuit passes through the Mean Solar Standard, but is broken in the clock in two places; one of these is united from about half a minute before to about half a minute after the minute hand marks sixty, and the other when the seconds hand indicates sixty seconds precisely. Both breaks can therefore only be together united at the commencement of each hour, and then only can a current pass. Each hourly current acts upon two electro-magnets. One of these automatically discharges the Greenwich time-ball at 1h. daily; the other is the electro-magnet of the hourly signal relay (shown to the left in the drawing) which completes various independent circuits, each in connection with a separate line of wire. One of these is in communication with the central telegraph station of the General Post Office, London; another extends to the London Bridge Station of the South-Eastern Railway Company. Along each line a galvanic signal passes hourly from the Observatory, day and night, for further transmission by apparatus under the control of other parties, and at this point (excepting in the case of the Deal time-ball to be hereafter spoken of) the special responsibility of the Observatory terminates. The small bell and galvanometer in the drawing marked respectively "Post Office Telegraphs" and "S.E.R. Hourly Signals," indicate at the Observatory the passage of the signals on these wires.

(To be continued.)

THE OPENING OF THE LOAN COLLECTION

THE Loan Collection was auspiciously opened on Saturday last by the visit of the Queen, and that it has exceeded all expectations is sufficiently shown by the opinions of the public press, which we have collected in another page. The Queen's visit is admitted on all hands to have been a complete success. Her Majesty herself, the Empress of Germany, and the other distinguished personages who accompanied her, showed a genuine interest in the collection, and especially in those apparatus to which their

attention was particularly drawn. The *Times* is "authorised to say that not only did her Majesty express to the Lord President of the Council, the Duke of Richmond, her gratification with the exhibition and with its success—exceeding any that could possibly have been anticipated of it—but that her Majesty desired to make known how much she was gratified by the manner of her reception and by the solicitude with which her visit was made interesting by the several scientific men who explained to her the nature of the objects exhibited."

Besides the German Empress, the Queen was accompanied by the Princess Beatrice, the Duke of Edinburgh, the Duke of Cambridge, Prince Edward of Saxe-Weimar, and among others who accompanied the Royal party during their tour round the collection were the Duke of Sutherland, the German, Austrian, Russian, and French and Spanish Ambassadors, the Italian Minister, the United States Chargé d'Affaires, besides a considerable number of the most eminent representatives of British and Foreign science, most of the members of the several committees, and many of the exhibitors.

The Queen was received at the south-eastern entrance to the Exhibition by the Duke of Richmond and Gordon and the Vice-President of the Committee of Council on Education, Lord Sandon, M.P., by the Commissioners of the Exhibition of 1851, upon whose premises the Exhibition is held, and by the members of the Duke of Devonshire's Committee on Scientific Instruction.

The Duke of Richmond and Gordon escorted the Queen round the Exhibition, pointing out objects of interest, and as the Queen entered each division of the galleries, gentlemen conversant with the various branches of science had the honour of being presented and of explaining to their Majesties and Highnesses the objects exhibited.

The Educational Collection was first examined, Mr. Heard showing the curious and extensive Russian pedagogical collection. In the Mechanical Section the famous primitive locomotives "Puffing Billy" and the "Rocket" attracted considerable attention. In this section also the ship *Faraday* was described by Dr. C. W. Siemens, who at the same time explained his bathometer, recently described in *NATURE*. The German ironclad, *König Wilhelm*, and other beautiful models illustrating the applications of science to shipbuilding, including a model of the *Serapis*, were described by Mr. E. J. Reed and the Duke of Edinburgh. In this same section Mr. W. Froude showed his models of the hulls of ships in solid paraffin, by which the valuable experiments were made which were recently described by him at length in *NATURE*. Prof. Tyndall's explanation of the lighthouses and fog-horns excited considerable interest, the Siren fog-horn being sounded to illustrate the usefulness of the signal. In the Fish Museum Mr. Frank Buckland was ready to explain the many interesting objects and processes shown there. As the party passed into the gallery of Electricity and Magnetism, the enharmonic organ of Perronet Thomson was heard from above playing "God save the Queen." In the section just mentioned M. Breguet, of Paris, gave a brilliant display of the electric light, while Prof. Carey Foster explained the great Haarlem natural magnet. Mr. Gramme's magneto-electric machines were shown Spottiswoode, and various telegraphic instruments by Mr. Culley. As her Majesty proceeded leisurely through the collection, Sir William Thomson showed his wonderfully ingenious tide-calculating machine, Joule's apparatus for researches in heat, and an apparatus for deep-sea soundings. Prof. Kennedy exhibited the important collection of kinematic models sent by Prof. Reuleaux, of the Royal Technical Academy, Berlin. The Walter type-composing machine was explained by Mr. J. C. Macdonald, Sir Joseph Whitworth described his millionth-of-an-inch measuring apparatus, while Mr. Chisholm explained various standard measures, a fine collection of standards made for the Russian Govern-

ment by Dr. Werner Siemens, being particularly observed. The Astronomer Royal, Sir George Airy, showed the telescopes of Sir W. Herschel and Lord Rosse, and a little telescope of Newton's.

Prof. Eccher exhibited some interesting memorials of Galileo, his bust, telescope with broken lens, and other objects, invaluable relics, which the Queen expressed her gratification to see generously confided to the care of this Department of her Government by Signor Peruzzi, the Syndic, and the City of Florence. Mr. John Evans, in the Geological Department, exhibited results of the Sub-Wealden boring; and in the spacious gallery and conference room devoted on Saturday to Geography, Sir Henry Rawlinson showed the Queen Livingstone's maps, and illustrated the route of Lieut. Cameron; Lieut. Cameron himself exhibited his charts of the interior of Africa. Capt. Evans, the Hydrographer of the Navy, showed the original logs of Captain Cook and the log of the *Bounty*, and Admiral Ommanney a log of Sir John Franklin. A collection of German maps, explained by Major von Vistinghoff, and the interesting collection of fossil leaves shown by Baron von Ettinghausen, of Graetz, were also inspected. In the Biological Department Prof. Burdon Sanderson and Dr. Lauder Brunton showed Marey's and other apparatus for recording and registering vital motion, and the instrument of Prof. Donders, of Utrecht, for measuring the velocity of thought. The musical instruments explained by Mr. J. Baillie Hamilton naturally attracted much attention. The other objects which attracted the attention of and were explained to the Queen and her party were Dalton's apparatus by Prof. Roscoe, Cavendish's and Black's balances by Dr. Frankland, early photographs by Capt. Abney, Russian heliographic plates and engravings by Baron von Wrangell, spectroscopes and radiometers by Prof. Guthrie, Otto von Guericke's air-pump and the Magdeburg hemispheres by Prof. Clerk Maxwell.

Before leaving the galleries, a telegram was despatched through one of the Morse instruments exhibited by our Post Office by the Empress Augusta of Germany, in the name of the Queen and herself, to the German Emperor in the following words:—"The Queen and the Empress have passed through the collection at the Exhibition of Scientific Apparatus and have been very much interested." Her Majesty the Queen desired that the same intelligence should be communicated to her eldest daughter the Crown Princess.

To quote the *Daily News* :—

"Throughout the course of the long promenade from the south-eastern entrance of the building in Exhibition-road to the exit in the Prince Albert's-road, neither the Queen nor the Empress of Germany exhibited the slightest sign of physical or mental fatigue. On the contrary, their majesties seemed rather inclined to remain for a space in converse with the learned expositors than to treat the inspection as a matter of ceremony."

During the visit, Sir Francis Sandford, Major Donnelly, Mr. Cunliffe Owen, and Mr. Norman Lockyer, were specially introduced to the Queen and Empress.

The Collection was opened to the public on Monday, and the number of visitors has been much greater than most people expected. They belong to all classes, and inspect the apparatus with evident interest and intelligence. The galleries, indeed, bear quite a lively aspect, and there is little danger of the Collection being a failure for lack of a public. We have no doubt, as its value and nature become known, the number of visitors will largely increase.

The first of the Conferences in connection with the Collection was opened on Tuesday, Lord Sandon making a short address of welcome.

"I have come down," he said, "to express my gratitude, and that of Her Majesty's Government, to the different men of science who are the real authors of what I may call the present success. I have had means of knowing

personally the extraordinary sacrifices of time and labour of those men of science in this country who have produced the success. It is gratifying, if only for one reason—it has shown what a feeling of intellectual brotherhood exists. We have had the highest men of science of this kingdom working together to produce this very remarkable exhibition. When we think of their zeal and self-sacrifice and determination, the country cannot be too grateful. And these qualities have not been confined to this country, but far beyond this island. It has been a matter of universal remark, the zeal, the determination, and friendly feeling which have been shown by men of science all over the world. We have—the Lord President and myself—done all that we could do to make this not a gazing place merely, but to give as much instruction as possible to those who desire to receive it. These Conferences will be a source of the greatest possible gratification, old friendships will be renewed, new friendships will be created between men of science of other parts of the world. These Conferences will, we trust, be much appreciated. The examination of the collections will be much assisted by the admirable handbooks which have been prepared by men of the highest capacity. Allow me also to express my sense of the very high service which the officers of the Science Department have rendered; their zeal, their highly cultivated intelligence, devotion of time and almost of health—we have reason to be proud of serving the Queen in concert with such officers. To the different men of science I express my hearty good wishes for exertions towards the continued success of the Exhibition. When those Conferences come to a close we shall feel that a great work has been done on behalf, not of this country only, but for the whole of the world."

Mr. Spottiswoode, the President of the Section of Physics, to which Tuesday was devoted, then delivered his inaugural address, which we are glad to be able to give below, as also that of Dr. C. W. Siemens, the President of the Section of Mechanics, which met on Wednesday. The other addresses on Monday were by Mr. W. Huggins, D.C.L., F.R.S., on the present state of Spectroscopic research relating to the Stars and Nebulæ; Mr. Norman Lockyer, F.R.S., and Capt. W. de W. Abney, R.E., on Spectroscopic Research in Solar and Molecular Physics; M. le Professeur Soret, on a Spectroscope with a fluorescent eye-piece; Prof. R. Bellamy Clifton, M.A., F.R.S., on Interference, and Instruments for the measurement of Optical Wave Lengths; Mr. H. C. Sorby, F.R.S., on the original form of the Spectrum-microscope, and the various subsequent improvements, and additional apparatus; the Earl of Rosse, D.C.L., F.R.S., on Zöllner's Photometer; Prof. Sir W. Thomson, LL.D., F.R.S., on the principles of Compass Correction in Iron Ships; M. Sarasin-Diodati, on De la Rive's Researches in Statical Electricity; and the President, on some recent forms of Polariscopic Apparatus.

In the Section of Mechanics, which met yesterday, besides the address of the President, Dr. Siemens, the following papers were read :—

Sir Joseph Whitworth, Bart., F.R.S., on Linear Measure; Mr. C. W. Merrifield, F.R.S., on Solid Measurement; followed by a communication from Prof. Tilser (Bohemian Institute, Prague); Prof. Sir W. Thomson, LL.D., F.R.S., on Electrical Measurements; M. Tresca (Sous-Directeur du Conservatoire des Arts et Métiers, Paris), on Flow of Solids; Prof. Kennedy, on Kinematics, &c.

The Chemical Section meets to-day, when, after the address of the President, Prof. Frankland, the following papers will be read :—

Dr. J. H. Gilbert, F.R.S., on some points in connection with Vegetation; Mr. W. F. Donkin, M.A., of Keble College, Oxford, on the Ozone Apparatus of Sir B. Brodie, Bart., F.R.S.; Mr. A. Fletcher, H. M. Inspector of Alkali Works, on the Gases discharged from Alkali Works; Professor Andrews, F.R.S., Experiments on Gases.

On the 19th and 24th the Section of Physics will again meet; Mechanics on the 22nd and 25th; Chemistry on the 23rd; Biology on the 26th and 29th; and Physical Geography, Geology, Mineralogy, and Meteorology on May 30 and June 1 and 2.

The following are the arrangements which have been made in the Section of Mechanics:—22nd May.—Mr. Barnaby, C.B., Director of Naval Construction to the Admiralty, Naval Architecture; Mr. W. Froude, M.A., F.R.S., Fluid Resistance; Mr. Thomas Stevenson, Lighthouses. 25th May.—Mr. F. J. Bramwell, F.R.S., Prime Movers; Mr. Hackney, B.Sc., Furnaces; Général Morin, Directeur du Conservatoire des Arts et Métiers, Paris, Ventilation; Professor Zetzsche, Electric Telegraphs.

A general idea of the arrangements in other sections will be obtained from the list in last week's NATURE, p. 34.

Besides these Sectional Meetings, several *soirées* have been arranged, the first of which, that of Physics, took place last night. A Geographical *soirée* will be held on Saturday night.

Several visits have, moreover, we believe, been arranged, including one to H. M. S. *Challenger*, which is expected home every day.

The following are the names of some of the distinguished foreigners who have come to London in connection with the Loan Collection:—*Germany*: Dr. R. Schöne, Herr Wilhelm Kirchner, Dr. Biedermann, Dr. Neumayer, W. Verners, C. Desaga, Herr Lingke, M. Borus, Dr. Julius Fettbach, Dr. H. Rohrbeck.—*Russia*: Baron von M. Wrangell, M. Heard, Dr. Selim Lemström, Capt. M. Rkeman, R.A., M. Ovsianikow, Prof. A. von Oettingen.—*Italy*: Il Com. Blaserna, Prof. De Eccher, Cav. Meucci.—*Austria*: Baron von Ettinghausen, Dr. Albert von Ettinghausen, Dr. Leopold Pfandner.—*Holland*: Prof. Dr. P. L. Rijke, Dr. J. W. Gunning, Dr. D. de Loos, Prof. Dr. J. Bosscha.—*Switzerland*: M. Soret, M. Hagenbach, M. Forel, M. Wartmann, Prof. Favre, M. E. Gautier, M. Th. Turretini, M. E. Sarasin, Prof. E. Hagenbach-Bischoff, M. R. Pictet.—*Belgium*: A. Renard, Prof. C. de la Vallée Poussin, Prof. G. Dewalque.—*Spain*: Señor Juan E. Riaño.—*Orange Free State*: His Honour, the President of the Orange Free State.—*France*: M. Tresca, M. Colaz, M. Breguet, P. Jablochkoff.—*Norway*: Prof. P. Waage.—*Sweden*: Dr. Christian Lovén.

SECTION—PHYSICS.

Opening Address by W. Spottiswoode, F.R.S., &c.

THE opening of this Exhibition may prove an epoch in the science of Great Britain. We find here collected, for the first time within the walls of one building, a large number of the most remarkable instruments, gathered from all parts of the civilised world, and from almost every period of scientific research. These instruments, it must be remembered, are not merely masterpieces of constructive skill, but are the visible expression of the penetrative thought, the mechanical equivalent of the intellectual processes of the great minds whose outcome they are.

There have been in former years, both in this country and elsewhere, exhibitions including some of the then newest inventions of the day; but none have been so exclusively devoted to scientific objects, nor any so extensive in their range as this. There exist in most seats of learning museums of instruments accumulated from the laboratories in which the professors have worked; but these are, by their very nature, confined to local traditions. The present one is, I believe, the first serious, or at all events the first successful, attempt at a cosmopolitan collection.

To mention only a few among the many foreign institutions which have contributed to this undertaking, we

are especially indebted to the authorities of the Conservatoire des Arts et Métiers of Paris, the Physical Museum of Leyden, the Tayler Foundation of Haarlem, the Royal Museum of Berlin, the Physical Observatory of St. Petersburg, the Tribune of Florence, and the University of Rome.

Among those in our own country, we have to thank the Royal Society, the Royal Institution, the Ordnance Survey, the Post Office, the Royal Mint, the Kew Observatory, besides various other institutions and colleges, which have freely contributed their quota.

To enumerate even the chief of the individual instruments of historical interest would be a task beyond the limits both of my powers and of your patience. But I cannot refrain from naming as especially worth notice among the astronomical treasures, a quadrant of Tycho Brahe, telescopes of Galileo, a telescope of Newton, some lenses by Huygens, one of Sir W. Herschel's grinding machines for specula, and a telescope made by himself in intervals between his music lessons during his early days at Bath, at a time when, to use her own words, his sister Caroline "was continually obliged to feed him by putting victuals by bits into his mouth." This also is probably the "mirror from which he did not take his hands for sixteen hours together," and with which he may have seen for the first time the Georgium Sidus. To come to later days, we have the original siderostat of Foucault, lent from the Observatory of Paris, a compound speculum by the late Lord Rosse, the photoheliograph from Kew, and from still more recent times a complete transit of Venus equipment, from the Royal Observatory at Greenwich.

Turning to other branches of physics, we have a "composed microscope," now nearly three centuries old, constructed in 1590 by one Zacharias Janssen, a spectacle-maker, possibly a connection, or at all events a worthy predecessor, of M. Janssen, the celebrated astronomical spectroscopist. We have an air-pump, and two "Magdeburg hemispheres," with the original rope traces by which horses were attached in the presence of the Emperor Charles V., in order, if possible, to tear them asunder, when exhausted by the air-pump. We have the air-pump of Boyle, the compressor of Pappin, Regnault's apparatus for determining the specific heat of gases, Dumas's globe for the determination of vapour densities, Fizeau and Foucault's original revolving mirrors and toothed wheels, whereby the velocity of light was first determined independently of astronomical aid, Daguerre's first photograph on glass, and the earliest astronomical photographs ever taken. To these may be added De la Rive's instruments for statical electricity; the actual table and appurtenances at which Ampère worked; and some contrivances as if fresh from the hands of Faraday himself.

Yet rich as is this part of our collection, and interesting as it might be made in the hands of one versed in the history and anecdote of the past, we must not linger even about these pleasant places. Indeed a museum of only the past, venerable though it might be, would be also grey with the melancholy of departing life. For science should be living, instinct with vigour and organic growth. Without a continuance into the present, and a promise for the future, it would be like a tree whose branches are broken, whose growth is stopped, and whose sap is dried. And if I may carry the simile a stage further, an exhibition of the present, with no elements of the past, would be like the gathered fruits to be found in the market-place, ready to hand, it is true, but artificially arranged. But when past and present are represented in combination, as has been attempted here, the very newest achievements will be found in their natural places as ripened and ever-ripening fruit in the garden from whence they have sprung.

In reviewing the series of ancient, or at least now disused, instruments, one thing can hardly fail to strike the attention of those who are accustomed to the use of the